Process of hydrogen isotope fractionation of methanol on interstellar grains

Akihiro Nagaoka[1]; Naoki Watanabe[2]; Akira Kouchi[3]

[1] Inst. Low Temp. Sci., Hokkaido Univ.; [2] Inst. of Low Temp. Sci., Hokkaido Univ.; [3] Inst. Low Temp. Sci., Hokkaido Univ

http://risu.lowtem.hokudai.ac.jp/

Recently, hydrogen isotope fractionations in several interstellar molecules have fascinated astronomers. For formaldehyde and methanol, even multiple-deuterated molecules were observed. The ratios of deuterated formaldehyde and methanol in the gas phase in some low-mass protostar are D2CO/H2CO~0.03 (Ceccarelli et al. 2002) and CH2DOH/CH3OH~0.9 (Parise et al. 2002) respectively. It is much higher than the ratio of atomic D/H (~10-5) in interstellar space. The reason for the high fractionations is an open question.

We deduce that the surface reaction on the grains plays an important roll in the hydrogen isotope fractionation of methanol. The methanol molecules are formed more efficiently on ice dust than in gas phase under the condition of a dense molecular cloud. We focus on an H atom substitution reaction of D atom as a process of concentration of D atoms in formaldehyde and methanol and then, performed the experiment on D atom irradiation to CH3OH.

The experimental procedure is as follows. The solid methanol was produced on an aluminum substrate cooled by a helium refrigerator to 10K in an ultra high vacuum chamber (~10-9 Torr). The D atoms produced by dissociation of D2 molecules by microwave discharge were irradiated to CH3OH ice. During the irradiation of D atoms, we measured the infrared adsorption spectra, in situ, with FTIR. We also performed the experiment on H atom irradiation to CD3OD ice to examine the reverse process (d-CH3OH to CH3OH).

As a result of the irradiation of D atoms, the multiple-deuterated methanol was formed effectively. On the other hand, the reverse process of H atoms was negligible in the experiment of H atom irradiation to CD3OD ice. The results indicate for the first time that the concentration of D atoms in methanol can proceed effectively on icy grains.